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A Monthly Review of Meteorology, Medical Climatology and Geography.

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THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. II. ANN ARBOR, FEBRUARY, 1886. No. 10.

CURRENT NOTES.

ENCOURAGEMENT OF CLIMATOLOGICAL OBSERVATIONS.—The Royal Meteorological Society had on display, at the International Inventions Exhibition, in London last year, the equipment necessary for a climatological station. This display was made with reference to fostering regular observations for climatological purposes and to increasing the number of stations. A small pamphlet as diswtributed, giving an account of what is needed for such stations, which also included some information of interest, such as a list of new instruments introduced into England since 1862. The list includes forty-three instruments, some of them being of great importance.

A CHANGE IN THE SYSTEM OF WEATHER WARNINGS DISPLAYED AT THE LEICESTER (MASS.) METEOROLOGICAL OBSERVATORY.—Although the system of weather warnings heretofore in use has given general satisfaction, still it has seemed to have some defects which it is hoped will be overcome by the new system. Among the defects of the old system may be mentioned the difficulty of distinguishing the centre pieces on the flags at any great distance, during light winds, and at times when the wind blew the flags in such directions as to conceal the centre pieces from the observer. In the new system each flag being of one color throughout can be distinguished at a much greater distance than the old flags, and can easily be seen at all other times when the centre pieces of the

old flags would be completely concealed. The new system requires two flags less than the old, thereby saving the expense of their purchase and occasional renewal. The new system of weather warning is made up as follows:

White Flag, clear or fair weather.
Red Flag. local rain or snow.
Blue Flag, general rain or snow.
Yellow Flag, above weather flag, higher temperature.
Yellow Flag, below weather flag, lower temperature.
Yellow Flag, not displayed, stationary temperature.
White Flag with black square in centre, cold wave.
The flags will be changed at **9** A. M. and **3** P. M

Those displayed at 9 A. M. will indicate the weather that may be expected for the next fifteen hours, and those displayed at 3 P. M. for the following day. This new arrangement of flags is to be tried at this station first, and if the experiment proves successful it is hoped that it will be adopted at other stations, unless a better arrangement is suggested, for it certainly seems as if the system described above has many advantages over the old system. A pamphlet will soon be issued giving a more detailed description of these weather flags and their uses, together with a description of the various instruments used, the formation and movement of storms, &c. J. BRADFORD SARGENT.

MAP OF MONTANA.—A new official map of this territory has just been completed by William P. Snow and published by George E. Boos & Co., Helena. It was constructed for the use of the territorial schools, in accordance with a resolution of the Montana legislature, and is approved by the governor. It is the freshest and undoubtedly the best map of the territory.

EARTHQUAKE ON PUGET SOUND.—This was on the night of the 8th and the morning of the 9th of December. A single shock was reported from Olympia, which was sharp enough to rouse every one. It travelled from east to west and was followed by a rumbling sound, which continued a few seconds. On Salt Springs Island three shocks were felt, in quick succession, one of them causing the dishes to rattle at a lively rate. On East Sound they were felt as follows: At 10:35 three light shocks, 10:40 two very

heavy shocks, accompanied by noises as of explosions. Many houses rocked like vessels at sea, china rattled, and pots and kettles swung. At 11:15 were two slight shocks, and at 11:50 one heavier shock. The waves were from the southwest. Every few minutes could be heard what sounded like the booming of cannon.

Ink for Registering Pens.—We are informed by Mr. Harold Whiting, of Harvard College, that the special kind of ink needed for the pens of self-registering thermometers and barometers can be made as follows:—To one ounce of glycerine add one or two grains of violet aniline; heat and stir till all is dissolved. Queen & Co., of Philadelphia, stated that "any aniline ink would do"; Mr. John Hubbard, of Cambridge, made the important addition of glycerine as a proper solvent for the aniline, and as the best means of preserving the fluidity of the ink. The ink supplied by the French instrument makers is not easily found in this country.

W. M. D.

The Giant Eucalyptus in France.—This very interesting tree has been generally introduced into southern France, and into Algeria. Many of the trees are now twenty-five or more years old and have attained a height of seventy-five or one hundred feet or more. The gigantic size of this tree, its remarkably rapid growth, the hardiness and tenacity of its wood, the medical properties of its exterior parts, all combine to make it a plant the usefulness of which can be compared with that of the potato. Indeed M. Charles Joly, whose note on the subject we have before us, suggests that this tree may make inhabitable, by its well known and acknowledged sanitary action, regions which could not be otherwise inhabited by Caucasians.

That the eucalypti have a decided influence on the atmosphere around them is no longer doubted. Their vicinity is relatively free from insects, and they protect from miasma. The former effect is undoubtedly due to their balsamic odors arising from essential oils which are not only produced in abundance in all the green parts of the plants, but are even exuded in many species as a sort of scurf, giving the trees their silvery appearance. Whether their destructive influence on miasma is due to the essential oils or to

the rapid growth and vigorous vegetation of the tree is yet an open question. Very likely, both characteristics have their influence.

The extracts from these trees are much employed for diseases of the mucous membranes. The Trappists of the Convent of Trois-fontaines, near Rome, and pharmacists make many forms of preparations from the resins, oils, and even leaves, which are much employed as disinfectants, antiseptics, and febrifuges. The amount of extract from the leaves varies with the species. According to M. Joly, M. Marchais of Antibes has tried a score of species to ascertain the difference in amount of extract. From 100 kilogrammes of the fresh leaves he obtained only 125 grammes from the rostrata, the occidentalis, and the calophyela; a greater proportion was obtained from the globulus, the siteroxylon, and the leucoxylon, viz., 1 kilogramme to 1 kilogramme and 125 grammes; finally, from the amygdalina he got 1.560 kilogrammes.

There are upwards of 150 species of the Eucalyptus known. They vary in size from shrubs to giants, and in habitat, from wet places to dry, hot plains, and from tropical to alpine situations. Those introduced so far have been most suitable for a dry, hot climate; there is still a vast field for the introduction of the others.

A Scientific Society of Mexico.—The first publication of the *Sociedad Scientifica "Antonio Alzate,"* has appeared. Its plan is a broad one, but the names of Don Alfonzo Herrara, Don Jesus Sanchez, Don Mariano Barcena, Don Miguel Perez, Don Rafael Aguilar (secretary) and others make a sufficient guarantee that the best scientific talent in Mexico is enlisted. Among articles already presented is one on ozone, and studies of rain in Mexico by Don Rafael Aguilar and various meteorological papers by Don G. B. y Puga. Among studies to be presented are: Description of Soconusco (Chiapas), by Don Enrique Mattern; Study of the Climate of Puebla, by Don Benigno Gonzalez. The society desires scientific exchanges.

Times of Vintage in France—It is interesting to have a long series of dates for any climatological fact. Such a series I find

in the *Bulletin Hebdomadaire* of the French Scientific Association for Nov. 22, 1885. It is the acceleration or retardation of the times of vintage at three stations in France in means for twenty-five years since 1575, or for three hundred years. The stations and the general means are, Dijon, September 28; Salins, October 11. In the following table the numbers are in days, and accelerations are indicated by the sign —, retardations by +.

	1575-99	1600-24	1625-49	1650-74	1675-99	1700-24
Dijon...............	+1	—1	—3	—5	—5	—2
Salins...............	+4	+2	0	—3	+1	—1
Aubonne............	—4	—8	—4	—5	+5	+8
	1725-49	1750-74	1775-99	1800-24	1825-49	1850-74
Dijon...............	+ 2	+3	+1	+7	+2	—2
Salins...............	— 2	0	—5	—1	+1	+2
Aubonne............	+10	+9	—1	+3	—4	—6

A simple inspection of the table shows that there has been no progressive change in climate, and the lack of agreement of the numbers among themselves shows that the variations must be due to secondary and irregularly acting causes. The author (M. A. Angot) reduced the dates to the proper years of the sun-spot periods and found only negative results.

Public Works of the General Government.—That these works need unifying and could be improved in many respects, no one would be disposed to deny. The civil engineers have already organized to exert some influence in that direction and met at Cleveland December 3–5 to effect this. The meeting was of delegates and, though small in numbers, represented the large body of civil engineers over the country. The business was left in the hands of an executive board. Mr. Wm. T. Blunt, of Cleveland is secretary.

Review of European Weather for November.—*Barometric Pressure.*—On the 1st there are three minima visible; one over Holland and Germany, another over the Baltic near Riga and a third northwest of Scotland, but on the 2nd the depression over Holland has disappeared. The second is also dispersed in the N.E. and the minimum in the N.W. becomes more intensive. A maximum has traveled from the south to Russia and another

appears in the S.W. The low pressure in the N.W. recedes to the north while the high pressure over Spain spreads over central Europe. A minimum now appears between this maximum and the high pressure in the east. Thus in the S.E. (over Italy) on the 7th, the maximum in the S.W. has joined that in the east so that the highest stand of the barometer is now over N.W. Germany. Slowly traveling in an easterly direction and accompanied by cloudy and foggy weather with light frosts the high pressure has reached on the 13th the vicinity of Kiew (Russia) when at the same time a minimum appears in the N.W. This disturbance quickly traveling in a northeasterly direction is central on the 14th near Haporanda in Lapland. A high pressure follows and on the 16th is central over Holland and Germany with light frosts. On the 17th it is situated over central Europe but on the 18th it recedes to Russia, while an intensive depression is passing over northern Europe. Frost is now general over central Europe and Scotland. The depression in the north disappears in a northeasterly direction and is followed on the 19th by a high pressure in the N.W.,while a minimum appears over the Bay of Biscay. Traveling easterly, the maximum just spoken of has reached on the 20th the vicinity of Copenhagen and on the 21st it is central near Odessa. The low pressure in the S.W. now spreads over the whole of west Europe joining a minimum in the north. On the 24th there is one depression in the S.W., another over Russia and a third over the Adriatic. A minimum is now central over Scandinavia. On the 25th the depression in the S.W. has become more intensive while the other two are dispersed. On the following day the maximum in the N.E. has spread as far south as Denmark, while the barometer at Valentia has fallen to 28.77. Causing severe storms over Britian, this depression travels in a northerly direction and on the 28th it is central near Shields on the eastern shore of Scotland; traveling easterly it has reached the south Scandinavian shores on the 21st. On this date another appears west of Ireland and on the 30th both depressions hover over the north Norwegian coast. Causing stormy winds over Britain, Holland and Germany.

Temperature: *Germany.*—Below the mean 1-4, 10-14, 15-27, above the mean 5-9, 15, 28-30; lowest on the 25th at Memel 9°, highest on the 30th at Munich, 59°.

Ireland: Valentia.—Below the mean 1-2, 4-7, 11-20, 22-25, 27-28, above the mean 3, 8-10, 21-26, 29-30, lowest on the 18th 35°, highest on the 3rd, 7th, 29th, 55°.

Sweden: Stockholm.—Below the mean 1-3, 15-17, 20-25, above the mean 4-14, 18-19, 27-30, lowest 16° on the 25th, highest on the 4th, 48°.

Russia: Petersburg—Below the mean 3-4, 5-7, 16-17, 20-30, above the mean 1-2, 5, 8-15, 18, 19, lowest on the 25th and 28th, 1.5°, highest on the 1st and 15th, 42°.

Lapland: Haporanda.—Below the mean 1-3, 13-17, 19-26, above the mean 4-12, 18, 27-30, lowest -28° on the 21st, highest 39° on the 12th.

On the whole a cold month, almost everywhere the temperature below the mean. M. BUYSMAN.

MIDDLEBURG, Holland.

ROYAL METEOROLOGICAL SOCIETY.—The usual monthly meeting of this society was held on Wednesday evening, the 16th instant at the Institution of Civil Engineers; Mr. R. H. Scott, F. R. S., President, in the Chair.

Mr. J. Hartnup, Mr. A. W. Preston, Mr. R. Sheward, and Mr. W. B. Worthington, B. Sc., M. Inst. C. E., were ballotted for and duly elected Fellows of the Society.

The following papers were read:

(1). "On the Influence of Forests on Climate," by Dr. A. Woeikof, Hon. Mem. R. Met. Soc. The first step toward a scientific investigation of the influence of forests upon climate was taken by the establishment of the Bavarian Forest meteorological stations. This example was followed by Germany, France, Switzerland, Italy and other countries. As a general result it was found that during the warmer season the air and earth temperatures were lower in the forest as compared with contiguous woodless places; that their variations were less and that the relative humidity was greater. Dr. Woeikof's discussion of this question shows that in the western portions of the Old World extensive forests materially influence the neighboring localities, and that the normal increase of temperature from the Atlantic Ocean toward the interior of the continent is not only interrupted by their agency, but they cause the summer to be cooler in regions

situated further in the interior than those nearer the sea. Hence forests exert an influence on climate that does not cease at their borders; but is felt over a greater or less district, according to the size, kind and position of the forests. From this it naturally follows that man, by clearing forests in one place and planting others in another, may considerably affect the climate.

(2.) "Report on the Phenological Observations for 1885," by Rev. T. A. Preston, M. A., F. R. Met. Soc. The year has been a very dry one, and this has acted in such a manner on vegetation that although the winter was mild, plants were very late in flowering and lasted only a short time. The bloom was often profuse and as bees and other insects could visit them, the crop of fruit was unusually great, the apple for instance, being often spoilt in quality from the enormous number on the trees; whilst in the case of wild fruits, the brilliant color of the bushes when in fruit was quite as beautiful as when in bloom. But at the same time the drought acted very prejudicially, especially to root crops and bush fruit, as well as strawberries. In the case of the root crops the seed had great difficulty in germinating, and the weak plants were at once overpowered by insect pests, so that the crops of turnips were generally complete failures. The insect pests also did much damage to bush fruit, while the drought prevented the strawberries from swelling. The corn did not suffer to any great extent, the dry season allowing the land to be prepared; and although the straw was often short, the yield was not unsatisfactory. A general absence of butterflies was noticed in some places In the south of England, the white butterflies were most abundant at that time, but the autumn butterflies were not so plentiful as usual.

(3). "Études sur les crépuscules rosées," by Prof. A. Ricco, of Palermo.

(4). "The Storm of October 15th, 1885, at Partenkerchen, Bavaria," by Col. M. F. Ward, F. R. Met. Soc. This was the most destructive storm which has occurred in this valley since the winter of 1821-22. The storm burst suddenly at 7 P. M. and lasted about half an hour, but in that short period nearly every house was unroofed, and it is computed that in one forest alone, above 250,000 trees were laid prostrate.

Health and Sunlight.—Dr. Bell, in his new work upon the subject of Climatology, says, "light is a collateral benefit of sea-air; and doubtless not a little of the rigidity of tissue and hardiness which characterizes the sailor is owing to the influence of light. Free access of light favors nutrition and regularity of development, and contributes to beautify the coutenance; while deficiency of light is usually characterized by ugliness, rickets, and deformity, and is a fruitful source of scrofula and consumption in any climate."

Light, like heat, it is well known, is but one manifestation of radiant energy. One part of the rays of the spectrum, isolated from the others, falling upon the retina may give to our perception the sensation of light. The same ray may have a discernible *chemical* action upon certain substances, blackening the salts of silver, for instance. If it fall upon certain other substances the manifestation of heat is produced. What its effects are depends upon the molecular constitution of that upon which it acts, or upon the molecular motion which it excites.

Plants cannot grow in total darkness. Waves of light impinging upon plants loosen their atoms, liberate oxygen and carbon and promote the assimilation of the latter.

The importance of sunlight to plants is thus readily seen. Heliotropism, or the sensitiveness of plants to the influence of light, is fully described by Mr. Darwin. There are but few plants, as the *Drosera rotundifolia*, but are possessed of this quality. "In several respects," says Mr. Darwin, "light seems to act on plants in nearly the same manner as it does on animals by means of the nervous system. With seedlings the effect is transmitted from one part to another. An animal may be excited to move by a very small amount of light, and it has been shown that a difference in the illumination of the two sides of the cotyledons of the Philaris, which could not be distinguished by the human eye, was sufficient to cause them to bend."

Not only may light exert its influence upon the nervous system, and secondarily upon the whole body, but upon all substances wherever molecular motion may be set up by the already existing molecular motion of light. N.

THE LITERARY NOTES.—Press of other matter necessitated the postponement of the literary notes for this month. They will appear next month.

UNFULFILLED PREDICTIONS.—That in the last thirty days (this is written Jan. 20) there have been several important slips in the predictions is as well known to the general public as to meteorologists. A "warm-wave" distinctly predicted did not appear, the cold areas have not always kept their appointments, and the path and destructive features of the cold area, which carried snow and frost southward to places where they were hardly known before, were not clearly foreseen. No meteorologist needs to be told that the motions of storm-areas (and especially "cold-waves") are erratic and predicters are occasionally led astray in spite of the greatest care; and also that it may happen, though improbable, that several of these irregularities fall together. The general public do not seem to understand this, and the writer has received not only newspapers commenting on the character of the predictions, but also letters, and even personal calls. Predictive meteorology is, as yet, purely empirical; we can only tell what will happen by what has happened. What appear to us as eccentricities of individual weather-areas undoubtedly have an explanation. When we can explain them, we will be able to predict them.

ELECTRICITY OF THUNDER CLOUDS.

A CRITICISM.

In a paper published in the *Journal de Physique* of January, 1885, a translation of which by Mr. McAdie appeared in the September number of this Journal, M. Pellat endeavors to show that the inductive action of a negative electrification of the earth, having sufficient density to account for the variation of potential actually observed close to the earth's surface, is a sufficient cause to account for the electrification of thunder clouds.

Without considering the question whether we can conceive of a cloud acting in any manner as a solid conductor, and hence whether it can be charged by induction at all, I propose to discuss briefly the argument by which it is sought to prove that the

induction of the earth-charge, assuming a cloud to be a good conductor, is sufficient to electrify thunder-clouds.

M. Pellat considers the formation of a cloud in the clear atmosphere, the latter being supposed unelectrified. Its upper and lower portions then separate under the actions of wind. These two portions may be supposed oppositely electrified through the inductive action of the earth, which we are to regard as negatively charged. As these portions drift about and change their relative positions they may acquire great difference of potential. M. Pellat then says that they may give disruptive discharges of the magnitude of lightning-flashes. The basis for this conclusion is the fact that M. Mascart, experimenting with two charged balls, found a limit to the difference of potential he could establish between them.

Disruptive discharges through a dielectric, as first shown by Sir William Thomson, are determined by stresses in the medium. When a conductor has been charged to a certain surface-density, the tension along the lines of force becomes greater than the dielectric can support, and, even if the body were alone in an infinite medium, it would give a brush discharge to the contiguous parts of the medium. In the experiments of M. Mascart, the greatest separation of the balls was six inches; the balls being nearer to each other than to other bodies, the density is greatest at their nearest point of approach, and hence the brush discharge occurs from that point. For so small a distance as six inches, the formation of the brush is sufficient to determine the complete discharge.

Now, in case of clouds miles apart this condition alone is not sufficient to determine a discharge, yet, let us suppose it were. We need then to seek an electrification for a thunder-cloud giving a surface-tension equal to the dielectric strength of air. The experiments of Sir William Thomson have given the dielectric strength of air as 9,600 grains weight per square foot. Or, the electric tension must reach a value of 657 dynes per square centimeter before a discharge can occur.

The surface-density is obtained from the surface-tension by the equation

$$\sigma = \frac{\sqrt{T}}{\sqrt{2\pi}}$$

Whence the cloud must have a surface density 28,000 times the average density on the earth as given by M. Pellat.

The electric force is related to the electric tension by the equation.

$$F = -\frac{dV}{dn} = \sqrt{8\pi T}$$

Hence the electric force must reach a value at least 128 C. G. S. units before we could even have a brush-discharge.

Taking this as our starting-point let us inquire how long a spark we could really get between clouds of such size as are found in nature

Let us consider two clouds and the earth as forming a system of three conductors. Let

$$\begin{cases} e_1 = \text{the charge of first cloud,} \\ e_2 = \text{the charge of second cloud,} \\ e_3 = \text{the charge of earth.} \end{cases}$$

$$\begin{cases} V_1 = \text{the potential of first cloud,} \\ V_2 = \text{the potential of second cloud,} \\ V_3 = \text{the potential of earth.} \end{cases}$$

The relations of these charges and potentials are completely expressed by the six equations

$$(1) \qquad \begin{cases} V_1 = p_{11}\, e_1 + p_{21}\, e_2 + p_{31}\, e_3 \\ V_2 = p_{12}\, e_1 + p_{22}\, e_2 + p_{32}\, e_3 \\ V_3 = p_{13}\, e_1 + p_{23}\, e_2 + p_{33}\, e_3 \end{cases}$$

$$(2) \qquad \begin{cases} e_1 = q_{11}\, V_1 + q_{12}\, V_2 + q_{13}\, V_3 \\ e_2 = q_{21}\, V_1 + q_{22}\, V_2 + q_{23} V_3 \\ e_3 = q_{31}\, V_1 + q_{32}\, V_2 + q_{33}\, V_3 \end{cases}$$

In general

$$p_{12} = p_{21} = p'$$

If the clouds are charged by induction

$$e_1 = -e_2 = e$$

Hence from (1)

$$(3) \qquad \begin{cases} V_1 = p_{31}\, e_3 + (p_{11} - p')\, e \\ V_2 = p_{32}\, e_3 - (p_{22} - p')\, e \end{cases}$$

Let us assume for convenience that the two clouds are equal and similar bodies and let p be the coefficient of self-potential of either when alone in free space, then

$$\begin{cases} p_{11} < p \\ p_{22} < p \end{cases}$$

Hence

(4) $$\begin{cases} V_1 < p_{31} e_3 + (p-p')e \\ V_2 > p_{32} e_3 - (p-p')e \end{cases}$$

Hence

$$V_1 - V_2 < (p_{31} - p_{32}) e_3 + 2(p-p')e$$

A fortiori,

(5) $$V_1 - V_2 < (p_{31} - p_{32}) e_3 + 2pe$$

If we further suppose, for ease of calculation, that the clouds are spherical

$$p = \frac{1}{r}$$

where r is the radius of either cloud.

And $p_{31}e_3$ and $p_{32}e_3$ denote the potentials which the clouds would respectively have, if free from charge, due to the action of the earth, say $V_1'\ V_2'$.

We may then write

(6) $$V_1 - V_2 < V_1' - V_2' + 2\frac{e}{r}$$

We now proceed to find a maximum value for e.

In general

$$q_{21} = q_{12} = q'$$

Initially the clouds were in contact and therefore

$$V_1 = V_2 = V'.$$

Hence from (2)

(7) $$\begin{cases} e = (q_{11} + q')V' + q_{13} V_3 \\ -e = (q_{22} + q')V' + q_{23} V_3 \end{cases}$$

In general

$$-(q_{22} + q') < q_{23}$$

Hence from the latter of equations (7) we obtain

(8) $$e < q_{23}(V' - V_3)$$

The introduction of a new conductor into the field diminishes the coefficient of induction between each pair. Hence, if q denote the value of q_{23} when the first cloud is removed out of the field, we have *a fortiori,*

(9) $$e < q(V' - V_3)$$

Now q is the coefficient of induction of the earth upon a spherical cloud of radius r small in comparison with the earth's radius,

the center of the cloud being at a height H above the earth's surface, where H is the height of the center of the lower of the two clouds when initially in contact.

Because of the great size of the earth in comparison with the cloud it is best represented by a sphere opposite an infinite plane.

The coefficient of mutual induction of a sphere and plane cannot be obtained in finite terms, but, if we consider an electrified point before an infinite plane, the system of equipotential surfaces to which it will give rise are not indeed spheres but nearly enough for our purpose and more nearly than an actual cloud.

Let us consider therefore an electrified point charged with quantity e at distance H from an infinite plane, the latter being maintained at potential zero. It is easily shown by the method of electrical images that the potential at any point on the same side of the plane is

$$V = e\left\{\frac{1}{S} - \frac{1}{S'}\right\}$$

where S is the distance to the electrified point and S' the distance to its image.

$$\frac{1}{S} - \frac{1}{S'} = \text{constant}$$

is the equation of our approximately spherical surface.

The charge induced upon the plane is $-e$.

Hence the coefficient of mutual induction is

$$q = -\frac{e}{V} = \frac{SS'}{S - S'}.$$

This equation holds for every point of the equipotential surface. We will apply it to the point nearest the plane and so choose the surface that in this case

$$S = r$$

$$\therefore \quad S' = 2H - r.$$

Hence

$$q = \frac{r(2H-r)}{2(r-H)}. \tag{10}$$

This is the coefficient of induction between a plane and a conductor of the form considered, circumscribing a sphere of radius r and tangent at the lowest point. We may regard it as a fair approximation to the value of q in inequality (9).

Hence

$$(11) \qquad e < \frac{r\,(2\,H - r)}{2\,(r - H)}\,(V' - V_3)$$

Hence from (6) *a fortiori*

$$(12) \qquad V_1 - V_2 < V_1' - V_2' + \frac{2\,H - r}{H - r}\,(V_3 - V')$$

If we now assume with M. Pellat that the field due to the earth is nearly uniform, we may without great error put

$$V_1' - V_2' = c\,h$$

where h is the vertical distance between the centers of the two clouds.

And similarly

$$V_3 - V' = c\,(H + r)$$

The value of c is given by M. Pellat as

$$c = 0.0045 \quad C.\,G.\,S$$

Hence

$$(13) \qquad V_1 - V_2 < c \left\{ h + (2H - r)\,\frac{H + r}{H - r} \right\}$$

Let D=length of spark.

Obviously this will be greatest when the cloud originally the lower is brought vertically above the other. Then, at the moment of discharge

$$h = D + 2r.$$

If we now put the difference of potential as equal to the very high maximum value of inequality (13) we have

$$(14) \qquad V_1 - V_2 = 0.0045 \left\{ D + 2r + (2H - r)\frac{H + r}{H - r} \right\}$$

We found above that the electric force must reach a value of 128 C. G. S. units and if D is found small in comparison with r we may write

$$F = 128 = \frac{V_1 - V_2}{D}$$

$$\text{or,} \qquad V_1 - V_2 = 128\,D.$$

Hence,

$$(15) \qquad 28443\,D = 2r + (2H - r)\,\frac{H + r}{H - r}.$$

If we now assume

$$\begin{cases} r = 2 \text{ kilometers} \\ H = 2.5 \text{ kilometers} \end{cases}$$

we obtain, solving for D,

$$D = 1.09 \text{ meters.}$$

This corresponds to the case of a mass of cloud 8 kilometers thick, having its lower surface but a half a kilometer above the earth's surface, being charged by induction, separating into two portions, turning completely over and then being able to give a lightning-flash *one yard* in length.*

If we suppose the cloud to discharge to earth, we may proceed as follows:

From the latter of inequalities (4) we obtain

$$V_1 - V_2 < V_3 - p_{32} e_3 + (p - p') e \tag{16}$$

Writing as before,

$$p_{32} e_3 = V_2'$$

we have *a fortiori*,

$$V_1 - V_2 < V_3 - V_2' + p e \tag{17}$$

Or, when the cloud is spherical

$$V_1 - V_2 < V_3 - V_2' + \frac{e}{r} \tag{18}$$

Considering the field sensibly uniform

$$V_3 - V_2' = c\,(D + r)$$

where D is as before the length of spark.

Hence, substituting for e from (11) and for $V_1 - V$ its value, we obtain

$$V_1 - V_2 < c\left\{D + r + \tfrac{1}{2}\,(2H - r)\,\frac{H + r}{H - r}\right\} \tag{19}$$

Or, putting the difference of potential as equal to this maximum and substituting the necessary condition

$$V_1 - V_2 = 128\,D$$

and for c its value 0.0045 we obtain

$$28{,}443\,D = r + \tfrac{1}{2}\,(2H - r)\,\frac{H + r}{H - r} \tag{20}$$

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*The density of the air being reduced at the height of 4.5 kilometers to perhaps one-half its value at the surface of the earth, the dielectric strength will be somewhat less and the length of spark may be increased to one and a half or two yards.

Whence if we assume the same magnitude of cloud formation as before, viz:

$$\begin{cases} r = 2 & \text{kilometers.} \\ H = 2.5 & \text{"} \end{cases}$$

we obtain, solving for D,

$$D = 0.55 \text{ meters.}$$

Or, the discharge would be a little more than *half a yard* in length.

Observe that in the above work we have assumed no less than four maximum values, some of them very gross, so that we may safely say that the result gives us the maximum possibility of disruptive discharge due to such an earth-charge and between clouds of such size and elevation as we have considered. Moreover we have exaggerated the phenomena of cloud formation beyond the usual case in nature.

I have developed the above theory to an extent perhaps tedious in order to show beyond peradventure that induction, even admitting that we are at liberty to suppose clouds good conductors, is utterly inadequate to account for the electrical energy of thunder-storms. We must look to some totally different cause as the source of the terrific forces of the lightning.

PARK MORRILL,
Signal Corps.

JOHNS HOPKINS UNIVERSITY,
Dec. 8, 1885.

THE MOUNTAIN METEOROLOGICAL STATIONS OF EUROPE.

A. LAWRENCE ROTCH, S. B., Member of the German Meteorological Society and Fellow of the Royal (British) Meteorological Society.

INTRODUCTION.

The International Meteorological Congress which met at Vienna in 1873 recommended "the establishment of permanent stations of observations on high mountain tops, if possible, provided also if possible with self-registering apparatus." Prof. Hann was requested to draw up a report on the subject which was presented to the Second International Congress at Rome in 1879. Prof. Hann there enumerated the existing mountain stations from which it appeared that there were but two mountain top stations in regular operation. As objects of study Prof. Hann mentions:

(1) Temperature. Daily periods and decrease of temperature with elevation. Radiation and insolation.

(2) Pressure. Daily periods. Hypsometry. Relation of the barometric maxima and minima on the earth's surface and at higher altitudes and changes of the variations of pressure with elevation. Form and inclination of isobars at different levels.

(3) Wind direction and velocity. Daily periods. Increase of velocity with elevation.

(4) Humidity. Daily periods. Decrease of vapor capacity with elevation.

(5) Hydrometeors.

The Roman Congress recommended the publication of future and existing series of observations *in extenso*. A form of publication had previously been indicated and the classes of stations defined as follows: "A station of the first order is an observatory in which, without the collection of observations from other stations, meteorological observations are conducted on a great scale, *i. e.*, either by hourly readings or by the use of self-recording instruments. Stations of the second order are the stations where complete and regular observations on the usual meteorological elements, viz., pressure, temperature and humidity of the air, wind, cloud, rain and hydrometeors, etc., are conducted. Stations of the third order, finally, are the observing stations, where only a greater or less portion of these elements are observed."

That there has been a great advance in the study of mountain meteorology will be seen from the following papers, which are the result of a visit to Europe last summer.

For the Continental stations the data will be expressed in the metric system.

THE GERMAN MOUNTAIN METEOROLOGICAL STATIONS.

The Brocken.

Situated in Lat. 51° 48′ N.; Lon. 10° 37′ E., is the highest of the Harz range, the most Northern mountains of Germany. It rises about 900 m. above the surrounding country, and has a height above the sea of 1141 m. Like all the Harz mountains the Brocken has a rounded outline and the slopes are gentle, averaging about

6° only, so that it has been possible to build a good carriage road 15 kil. long, to the summit, over which runs a post-wagon, the highest indeed in North Germany. There is also a telegraph line to the top. Unlike the Alps, the north side of the mountain is steeper than the south side. It is clothed with fir trees almost to the top, which is flat and plateau-like, falling off only 15 m. in a distance of 200 m. from the highest point, and is covered with granite blocks strewn about in wild confusion, between which grow grass and moss. On the highest part of the plateau stands the Brocken Hotel, a long two-story stone structure having in front a wooden tower 17 meters high from which visitors can enjoy the view. It is said that during the summer no less than 30,000 visitors ascend the Brocken.

As the Brocken is the highest mountain in Germany N. of Lat. 51° it is of great importance as a meteorological station. The air currents strike it on all sides undeviated and unhindered by friction with the ground. It lies in the region of greatest cloud formation, which moderates the climate, and in the track of the moist southwest, west and northwest winds which give it a very large precipitation. The violent northwest gales which blow on the coast of the North Sea strike the Brocken with full force, whereas by the time they reach the mountains further inland, such as the Schneekoppe, their force is diminished. For these reasons the Brocken experiences more frequent fogs and stronger winds than many other higher mountains of Germany.

Meteorological Station.—A meteorological record was kept by the hotel landlord, with a few breaks, from 1836 to 1869, the observations being made at 6 A. M., 2 and 10 P. M. From November, 1880, to October, 1882, observations were made at 8 A. M., 2 and 8 P. M., in the summer by a waiter and in the winter by the watchman, and transmitted to the Prussian Meteorological Institute in Berlin and published in the annual volume of *Preussische Statistik.* Frequent changes of observers caused breaks in the observations, which were about to be discontinued when Dr. Assmann, director of the Observatory of the Magdeburgische Zeitung, induced the Brocken Club, a local organization, to subscribe 400 marks, by which the observations were continued during the winter by an intelligent waiter, while in the summer they were kept

up by the postmaster. In order to be, to a certain extent, independent of the observer, the registering barometer and thermometer of Richard Brothers of Paris, were obtained for the station last winter. As these little instruments are much used abroad the following brief description of them is given: The barograph consists of eight small aneroid boxes, placed one above the other, which by means of a pen on the end of a lever registers the variations of atmospheric pressure upon a paper-covered drum, which is revolved on a vertical axis once a week by clock-work inside. The thermograph has a curved brass tube filled with alcohol, which, when the temperature rises, straightens by its expansion and re-curves again when the temperature falls and the alcohol contracts. The motion is registered on a drum in the same manner as for the barograph. The apparatus is enclosed in a water-tight box, which is here fastened to a post 1.7 m. above the ground on the north side of the hotel. In winter the box becomes encased with ice, but it would be useless to enclose it in a louvre shelter, since this, too, would soon be transformed into a box of ice. At the time of the writer's visit, in July last, a sling psychrometer was used by the postmaster at the hours of 8, 2 and 8. For obtaining the humidity in winter there is a Koppe hair hygrometer. A Fuess closed cistern barometer, having a reduced scale so that but one adjustment is necessary, was read at the same hours. The results of the tri-daily observations, comprising barometer, (corrected for temperature only); air temperature and humidity; maximum and minimum temperatures; direction of wind and its force on Beaufort's 12-part scale; precipitation; kind and quantity of cloud (estimated on a scale of 10); are sent monthly to Dr. Assmann in Magdeburg.

Great difficulty has always been experienced in measuring the precipitation on the Brocken in winter, and the older measurements are very incorrect. The great velocity of the wind sweeps the snow out of the gauge as soon as it falls. Frost-work, which here forms very rapidly, collects in the mouth of the gauge and diminishes its receiving surface. An experiment made by Dr. Assmann with a heated gauge placed on the chimney of the hotel was unsuccessful, partly, because at times the smoke was so hot that it not only melted the snow but also evap-

orated the resulting water, and partly, because the steep pitch of the roof gave the snowflakes an upward motion, so that very little was caught. A new gauge, heated by petroleum lamps, was tried last winter by Dr. Assmann, and proved very successful. The gauge may be moved about and secured in the lee of the building by rocks placed on its projecting feet. By means of double casings the lamps will burn in a gale, and when the gauge is nearly submerged in snow. A glass window enables it to be seen if the lights are burning. The warming of the receiver checks the formation of frost-work and immediately melts the snowflakes as they fall. The resulting water passes into a cold collecting basin, where it undergoes no evaporation by the heat and may even freeze.

Dr. Assman has experimented with an anemometer placed on the top of the tower. This instrument, which had been carefully tested, gave some astonishing velocities. During a storm in October, 1884, the velocity of the wind reached 50 m. per second, and the mean for an hour was 39 m. per second. Owing to the frost-work in winter, which incrusts everything, it it has been impossible to maintain an anemometer working continuously. A solution of chloride of calcium in glycerine has been tried to keep the spindle and rubbing parts free, but the cups became entirely filled with ice. It is now hoped to keep them clear by making the walls double and passing air heated by a spirit lamp below up through a hollow shaft to the cups. Dr. Assmann often visits the station, and has made some interesting investigations on frost-work formation in which he studied the cloud particles, under the microscope, and satisfied himself that they were composed of small drops of water and not of hollow bubbles, as was formerly believed. He proposes to carry out researches on twilight and the reddish-brown ring around the sun.

Results of Observations.—According to the data furnished by the older observations which have been discussed by Dr. Hellman (Klima des Brocken in *Kettler's Zeitschrift für Geographie*) the mean annual temperature is 2.4° C, which is about that of Tromsö in Lat. 70° N., the coldest month being January, with a mean of —5.4°, the warmest July with 10.7°. The highest temperature observed has been 27.7°, and the lowest —28.0°. It is evident that

the Brocken plateau from its powerful insolation must raise the air temperature considerably, especially in summer. Long periods of cold weather are relatively not more frequent than at lower levels; one of the coldest on record was in January, 1838, when for eighteen days the mean temperature was below —19°. The decrease of temperature for 100 m. is 0.67° C in the Harz, which is very rapid, and greatly exceeds that in the Alps and on some of the German mountains. At times, remarkable inversions of temperature have been noted; thus, on one occasion, during an anti-cyclone in winter, the thermometer stood 16° C higher than it did 1000 m. below. As a rule, the last frost and snow on the Brocken occur the end of May and the first early in October, so that, ordinarily, there are four months free from them. The usual depth of snow in winter, where it has neither drifted nor blown away, is from 1.5 m. to 2 m., but the drifts frequently reach the roof of the hotel. It is probable that the Brocken received two and a half times as much precipitation as the places at its base, and that the quantity is something like 1900 mm. annually, though, owing to the difficulty of measurement in the winter months there is, as previously stated, great uncertainty as to the amount. The frost-work is a not unimportant factor in the precipitation. It forms with great rapidity upon the windward side of every object, whenever the summit is enveloped in clouds and the temperature is below 0° C. It has been known to form at the rate of 50 cm. in 24 hours, and a telegraph pole has been covered to the thickness of nearly 3 m. Thunderstorms seldom pass over the summit, but the St. Elmo's fire is not unfrequently noted. The prevailing winds are from the west and southwest, and calms are very rare. Calling 4 a hurricane, the mean strength of the wind for the year is 1.8, being 2.1 in winter and 1.7 in summer. The foggy days reach the large number of 275 annually, though this is not much larger than for the Schneekoppe, and some other mountains. The famous "Spectre of the Brocken" is produced when the fog lies lower than the highest peak, and the shadow of the observer, greatly magnified, and the head surrounded by a halo, is seen projected upon it by the rising or setting sun. The phenomenon is only seen, however, about a dozen times in the course of a year.

The Brocken observations, together with those at the corresponding plain station of Nordhausen (222 m.) were published in the *Ergebnisse der meteorologischen Beobachtungen* of the Prussische Statistik previous to 1883 and a resumé of the old observations on the Brocken in the Report for 1880.

The Schneekoppe.

Situated in Lat. 50° 44′ N. and Lon. 15° 44′ E. is the highest peak of the Riesengebirge and is the highest point of Germany north of the Danube, attaining an altitude of 1599 m. above the sea. The upper part of the mountain is a three sided pyramid, covered with broken mica slate, rising abruptly 190 m. from the plateau of the Koppenplan on the west. From the latter a steep zig-zag path leads to the summit, which extends beyond the Prussian boundary into Austria and presents a surface, slightly convex from east to west, 80 paces long and 60 broad. In the middle is a stone chapel which dates from the 17th century. The two inns, one on the Prussian, the other on the Austrian side, are crowded during the summer, when it is estimated that the Schneekoppe is visited by 10,000 people. Besides a postoffice there are two telegraph offices, one German the other Austrian, and, last August the little hamlet presented a very animated appearance. This mountain, on account of its isolated situation and pointed summit, offers unusual advantages for meteorological observations, though it is not until recently that regular observations have been made there.

Meteorological Station.—The earliest observations date from 1786. A series of tri-daily observations at 7, 12 and 8, was maintained during the summers of 1824–33, and during the summer of 1863. Since July 1880, the Schneekoppe has been a second order station of the Prussian Meteorological Institute, the observations being taken at 7 A. M., 2 and 9 P. M., by the telegraph operator who receives about 300 marks per year as compensation.

The meteorological station is in the Austrian telegraph office, a wooden building, on the north side of which is the thermometer shelter, open at the bottom and having a door in front. In it at a height of 2 m. from the ground are a wet and dry bulb and a maximum and minimum thermometer all made by Fuess of Berlin. His Kew "station" barometer is employed also. There is

a small vane for giving the direction of the wind to eight points of the compass; its force is estimated on a scale of 6. On account of the high wind, the measurement of precipitation is difficult. At present, a gauge similar to those used in Russia, is placed west of the building, supported on an iron tripod 1.2 m. above the ground. It consists of a zinc cylinder, one-half m. high, painted white, with a brass rim presenting a receiving surface of one-twentieth square m. Below is a smaller collecting cylinder about 12 cm. in diameter, divided off by a conical perforated diaphragm, with a cock at the bottom by which the water is emptied into the measuring glass, graduated to 0.1 m.m. Snow is melted and measured as rain and the gauge is read daily at 2 P. M.

The full form for the record of the observations contains the following items: Barometer, actual and reduced to 0° C.; maximum and minimum thermometers read at 9 P. M.; wet and dry bulb thermometers; absolute and relative humidity, calculated from Jelinek's tables; amount of cloud on a scale of 10 and direction from which moving; direction and force of wind; precipitation, kind and amount. From October to April the temperature of the earth's surface is observed three times a day. For the record of the precipitation and other atmospheric phenomena the symbols adopted by the International Meteorological Congress are used. The record is sent at the end of the month to Berlin.

The optical phenomena here noted by Dr. Kremsen (see German *Met. Zeitschrift*, March–April, 1885) seem to merit further study. Under the contemplated re-organization of the German, and particularly of the Prussian meteorological service, it is probable that the Schneekoppe, being so well adapted for the purpose, will be made a station of the first order.

Results of Observations.—The result of the ten years' summer observations are given in Galle's *Grundzüge der schlesischen Klimatologie* (Breslau, 1854). The present observations, together with the corresponding series made in the town of Eichberg in the Hirschberg valley, 18 kil. north and 1,251 m. below the Schneekoppe are published in the annual volume *Ergebnisse der meteorologischen Beobachtungen* of the Preussiche Statistik. From these it appears that the mean pressure on the Schneekoppe for 1883 was 626 m.m.

and the mean temperature—0.5°, which is about that of Irkutsk in Siberia. At Eichberg the mean annual temperature was 6.6° giving a decrease of 0.56° per 100 m. of elevation, which is a lower rate than for the Harz. The coldest month was March with a mean temperature of—10.4°, the warmest, July, with a mean of 8.4°. The absolute extremes were—23.8° and 22.3°. The mean relative humidity for the year was 86 per cent.

The precipitation, on account of the inland situation of the Schneekoppe, is not so large as for the Brocken, aggregating about 1,400 m. annually, which is nearly twice as much as Eichberg at its foot receives. It occurred in 1883 on 192 days. Snow falls on an average nine times in the four summer months, and in winter reaches a mean depth of three meters. Frost work forms to some extent. The number of foggy days is nearly the same as for the Brocken, having in one year amounted to 272, but the peculiar so-called "Spectre" of the latter is very rarely seen here. The prevailing wind, according to the observations of 1883, was southwest, the month having the strongest winds being December, with a mean force of 3.4 on the 6-part scale, the lightest winds, represented in the same way by 2.0, occurring in June. The mean wind force for the year was 2.4.

The Wendelstein.

Situated in Lat. 47° 42′ N.; Lon. 12° 1′ E. is about 50 kil. southeast of Munich on the north edge of the Alps, higher than the surrounding mountains and completely separated from them. It rises about 750 m. as a cone above where the river Inn makes its exit from the mountains, with its steepest side to the northeast. At a height of about 1,730 m. above the sea is a comparatively level pasture of about 60 ares on which has been built the Tourist House. The top of the mountain is split into several rocky pinnacles, scantily clothed with grass, which are all subordinate to the highest one. Upon this, at an altitude of 1,837 m. above sea level, is a small plateau about 20 m. long by 3 m. wide where stand a little chapel and a cross. The path from Bayerisch Zell, on the south, is 8 kil. long and tolerably good as far as the inn. From there to the peak before mentioned the rise is so steep that it was necessary to cut steps and to stretch a wire rope alongside

to enable tourists to make the ascent. In winter this part of the path is practically impassable.

Meteorological Station.—This, the highest meteorological station in Germany, was established in Nov. 1883, as a second order station of the Bavarian Meteorological Service by the German-Austrian Alpine Club which appropriated 400 marks for the purpose, and this sum was afterwards increased by private subscriptions. The Tourist House, which serves to contain the instruments, is situated, as before stated, upon a level piece of ground, 1728 m. above the North Sea, and backs against a steep wall of rock which rises 109 m. higher, forming the veritable summit before described. At a distance of 15 m. from the front is another much lower mass of rock. It was therefore impossible to place the instruments on the north of the building after the manner of the other Bavarian stations, and it was necessary to have two thermometer screens, one on the east, the other on the west side of the house. They are zinc cylinders with conical roofs, extended 1 m. from the wall by rods and are 4.1 m. above the sod below. These screens are of the pattern used at the Bavarian stations but are here more strongly braced to resist wind. To read the thermometers, the cylinder is swung in front of the window of an unheated room, so that they can be seen through an opening in the cylinder, which, when the cylinder is in place, faces the south. At present, a maximum and minimum thermometer only are employed and they are read at 8 A. M., 2 and 8 P. M., in the morning the thermometers on the west side, in the evening those on the east side being used. At 2 P. M., the temperature of the open air is taken by the sling psychrometer of Rung of Copenhagen. For determining the humidity there is a Koppe hair hygrometer which is kept in a cold room with wet muslin back of it, so that the hair is maintained in good condition, and it can always be seen whether the instrument registers correctly at saturation. Half an hour before the time of observation, the hygrometer is placed in a screen outside a window on the shady side of the house. The barometer is of the Forlin type and was made by Böhm & Wiedemann of Munich. It has a micrometer screw for reading and is placed in an unheated corridor where it cannot be reached by sunshine. Besides this normal barometer there is a Richard barograph which has given

continuous records since Nov. 1884. A similar instrument is at Bayerisch Zell, not far distant horizontally, but 630 m. lower. The direction of the wind is obtained from a wind vane elevated 2 m. above the rocky pinnacle in front of the house. Its force is obtained from a Wild pendulum pressure plate hinged to the spindle of the vane and turning with it. The plate is therefore normal to the wind when at rest. It moves over a graduated arc with eight divisions representing wind forces. On account of the increasing obliquity the higher numbers can not be correctly shown and the wind scale is therefore estimated up to 12. This instrument is much used in the Continent. The rain gauge is of the general model used at the Bavarian stations, having a receiving surface of one-twentieth square m. and is hung between two posts at a height of 1.4 m. above the ground. The water passes into a flask holding three liters, which is protected from evaporation and possible leakage by a zinc cover attached by a bayonet joint to the receiving cylinder. The water in the flask is measured in a graduated glass daily at 8 A. M. There are a number of divided rods in the neighborhood for the daily measurement of the depth of snow on the ground.

The regular items for the tri-daily observations which are made at 8 A. M., 2 and 8 P. M., are as follows: Pressure; temperature; absolute and relative humidity; direction and force of wind; kind and amount of cloud and direction from which moving; precipitation. The international symbols are used and the meteorological day begins and ends at 8 P. M.

The observations are made by the hotel watchman who is alone in winter and receives 100 marks extra from the Wendelstein Alpine Section, besides board. In summer he is sometimes relieved by the inn keeper. The carrying on of the correspondence is attended to by members of the Club and the reduction and calculation of the means are done at the Central Station in Munich, where the record of observations is sent each month.

The writer cannot forbear to mention the pleasant memories which he will always have of the Wendelstein on account of his visit there with the German Meteorological Society in August last. Among the company were such distinguished meteorologists as Dr. Neumayer, director of the Deutsche Seewarte, Prof. Hann of Vienna,

Director Billwiller of the Swiss Meteorological Service, Prof. Köppen and Drs. Sprung and Assmann. The latter has already given an account of the visit to this high station in the September number of his admirable magazine "Das Wetter." It is the opinion of Dr. Assmann, as well as that of the other authorities, that the mass of rock back of the inn, which receives the full effect of the sun, must exercise by radiation a considerable effect on the temperature of the surrounding air, and that the observed temperatures should not be regarded as identical with those which would be obtained upon an isolated peak in the same place. It was also thought that it would not be a matter of great difficulty to make a path which should render the highest point of the Wendelstein accessible in winter, and that it would then be an admirable place for an observatory in which to place registering apparatus. At any rate, it would seem that the cost of such an observatory would be more than repaid by the value of the results obtained.

Results of Observations.—As is common at high altitudes, the mean temperatures are found to be low and the ranges small. All the months are colder than in the low lands. July is not so warm as May in Munich, while the months from November to February, together, average colder than January there. The snow in winter is deep, but there is little frost-work.

The first year's observations are published in full, according to the international form, in the *Beobachtungen der meteorologischen Stationen im Königreich Bayern* for 1884. They show a mean pressure of 619 mm., a mean temperature of 1.2°, with extremes of —19.3° and 24.6° January was the coldest month, with a mean of —4.9°; July the warmest, with 9.6°. The total precipitation was 1492 mm., very unequally distributed through the months. It fell on 195 days. The prevailing wind was N. W. This data for the Wendelstein, being based only on one year's observations, and that an exceptionally warm year in southern Bavaria, is not to be regarded as establishing the normals.

Other High Stations.

Are the Schneegruben-Baude (1425 m.) and the Glatzer-Schneeberg (1210 m.), both in Prussia. The Hohenpeissenberg (994 m.)

in Bavaria should be mentioned as one of the few summit stations. These are all stations of the second order and observe three times a day.

(TO BE CONTINUED.)

AN EXPERIMENT IN LONG RANGE PREDICTION.

In a series of articles in this Journal, the writer has attempted to show that there are well defined weather changes of long period; and, in order to put this conclusion to the most crucial of tests, it was decided to attempt predictions based on such changes.

The changes in question, though each in itself apparently regular when separated from other influences, in their combined actions present an extremely complicated series of movements; but it was hoped that the actions might be so unraveled and extended that predictions, even though crude, of the coming weather might be made, and in this possibility centers their chief and most absorbing interest.

The predictions attempted were made on the 24th of each month and were intended to cover the succeeding month. They were divided into three classes. 1st, the general or average of the month, 2d, the average of ten days intervals, and 3d, more detailed predictions covering intervals of a day or two.

On the 24th of April after summing up the meteorological conditions existing at the time, it was stated that, "everything at present seems to point toward a warm and probably dry May in the eastern United States."

The charts and tables accompanying the Siginal Service *Monthly Weather Review** show that as regards temperature the prediction was a total failure, the temperature being below normal over the whole of the eastern half of the United States. The rainfall was below normal in New England, Florida, the Ohio Valley, and Upper Lake Region; and above, in the Middle Atlantic States, the East Gulf States, Tennessee, and the Lower Lake Region; so that the prediction as regards precipitation was about 40% verified.

The prediction for June was as follows: "If we suppose the

*I presume the majority of my readers have access to the *Weather Review.*

United States divided into three equal parts by lines running north and south, it is probable that in the central part the mean temperature and pressure for June will be below the normal and precipitation above; while in the eastern part the pressure and temperature will probably be above normal. Going more into detail, it is probable that between the 1st and 10th of June the period of high pressure which prevailed over the eastern part during the middle and latter part of May will be replaced by lower pressure and cooler cloudy weather, followed in turn by a period of higher pressure and warmer weather between the 15th and 25th. The remaining parts of the month will probably be nearer normal."

The *Monthly Weather Review* shows that over the whole of the central part of the United States the average pressure was above the normal and the temperature below, while the rainfall was above normal over about 50% of the area. The average monthly pressure was above normal over about 90% of the eastern third of the United States, and the average monthly temperature was below normal over the entire eastern third.

In estimating the percentage of verifications for the ten day intervals, it is impossible to obtain reports from all of the Signal Service Stations, so that it is necessary to be content with reports from a few widely separated stations selected at hap-hazard; but I do not think any one who has drawn curves showing the changes of temperature and pressure at widely separated stations will doubt that these pretty fairly represent the whole. I feel confident that returns from all the stations would not alter the average estimates more than five per cent.

I showed in the July Journal that the prediction for the first ten days was 100% verified as regards pressure and about 30% as regards temperature. For the second interval of ten days (June 16–25), the average pressure at five stations given in Table I, shows a verification of 100% as regards pressure, and Table II shows a verification of 80% as regards temperature.

The average pressure of the remaining parts of the month was nearer normal at three of the stations and not nearer at two, giving an approximate verification of 60%. The average temperature of the remaining parts of the month in the same way give

an approximate verification of 40%. Summing up we get a verification of the ten days interval as regards pressure of 87%, and as regards temperature of 50%.

TABLE I.

AVERAGE PRESSURE.				
	June. 1–10	June. 15–25	June 28 to July 10	July 11–25
Boston	29.81	30 00	29.87	29 96
Washington	9 97	30 00	2[illegible].96	29.9[illegible]
Savannah	29.96	30.11	30 02	30 00
Nashville	29 93	30.08	30.03	29 98
Chicago	29 92	30.06	29 98	29.93

TABLE II.

AVERAGE TEMPERATURE.				
	June. 1–10	June. 15 25	July 1–10	July 11–25
Boston	59.5	69.7	69.0	73.0
Washington	6[illegible] 6	[illegible]3.8	74 9	[illegible]9.7
Savannah	79 1	79.2	80.7	82.6
Nashville	[illegible]6.5	73 5	74.0	79 6
Chicago	61.2	66.0	71.0	72.5

The prediction for July was as follows: "The area for which the following forecasts are attempted is the part of the United States east of the Mississippi River. It is probable that the area of high pressure which prevailed over this area during the middle of June will be replaced the last few days of June and the first ten days of July by a period of generally lower pressure accompanied by considerable rainfall. It is also probable that over a large part of this area the mean temperature of the first ten days of July will be lower than during a period of corresponding length near the middle of June. This area of cooler weather will most probably include New England or the Eastern States. The area of low pressure will be followed the next fifteen days by a period of generally higher pressure with less rainfall and a higher mean temperature over at least a portion of this area. Attempting still greater detail for the first part of the month, it is probable that a comparatively high pressure with fair weather will prevail about July 1st and between the 3d and 6th decidedly lower pressure will prevail with much rainfall. Higher pressure with fair weather will probably again prevail between the 7th and 8th, followed by low pressure with rain between the 10th and 13th, and a decidedly high pressure area about the 14th. The depression which will probably pass between the 3d and 6th and 10–13th will be preceded by a day or two of hot sultry weather, and followed by a day or two of cool weather."

No general prediction for the month was made. Turning to Table I it is seen that the average pressure of the last few days of June and first ten days of July was lower at all the stations than from June 15th to 25th. It is also seen that the average pressure

is higher again from July 11th to 25th at two-fifths of the stations. The average of the two intervals gives a mean verification of 70%. The prediction of the first ten days as regards temperature was that an area of cooler weather would most probably include the Eastern or New England States. The average temperature of the first ten days at Boston as compared with June 16th to 25th (see Table II) show that an area of cooler weather covered at least a portion of this area, and I think the prediction can be safely estimated as 50% verified. The temperature of the next fifteen days was higher at all of the stations and is estimated as 100% verified.

The more detailed prediction as shown in the August Journal was about 90% verified.

The prediction for August was as follows: It is probable that the average pressure over the eastern half of the United States for the month of August will be lower and rainfall greater than that of July. It is probable that the average pressure of the first ten days will be lower than that, both of the ten days which will follow the middle of July and of the ten days which will follow the middle of August. On one or two of these days the pressure will probably be quite low with heavy rainfalls in some sections. * * * * * Some of the indications seem to point to the conclusion that August will not on the whole be an abnormally hot month.

The *Monthly Weather Review* shows that the prediction as regards pressure was 50% verified; the rainfall was verified in every district except Tennessee, and the West Gulf States; and the temperature was 95% verified.

The accompanying table III will enable a comparison of the ten day predictions to be made.

TABLE III.

AVERAGE PRESSURE.	July 15-24	Aug. 1-10	Aug. 15-24
Boston	29.98	29.99	29.93
Washington	30.01	29.91	30.01
Savannah	30.01	29.96	30.01
Nashville	30.01	29.9[illegible]	29.99
Chicago	29.95	2[illegible].[illegible]7	29.96

It is seen that the prediction was fulfilled at every station except Boston, and must certainly have been fulfilled over 90% of the territory.

As predicted, on one or two of the first ten days (2d and 3d) the

pressure was quite low—lower than at any time during the month over most of the area—and the rainfall was heavy.

The prediction for September was: "The average pressure of September will probably be considerably higher than that of August, over the whole, or nearly the whole of the United States, and the month will on the whole probably be a pleasant one. In the eastern half of the United States, the average pressure of the first part of the month, and especially of the first week will probably be much lower than that of any similar interval during the month, and it is probable that during this interval the weather will pretty generally be cool and rainy. Near the middle or between the middle and latter part of the month the average pressure will probably be quite high, and on some days higher than at any time since June. Some of my data seem to indicate that the lowest pressure of the month will occur between the 2d and 5th, and if so will be accompanied by heavy rain, etc."

The *Weather Review* states that the average pressure of September was higher than that of August, over about 90% of the United States, and the charts show the temperature to have been approximately normal over the country.

Table IV shows that the average pressure of the first part of the month was lower than that of any similar interval during the month except at Savannah and Nashville, and the prediction is estimated as 60% verified. The prediction of higher pressure for the middle of the month was entirely fulfilled (100%.)

TABLE IV.

AVERAGE PRESSURE.			
	Sept. 1st–10	Sept. 11–20	Sept. 21–30
Boston	30.00	30.05	30.01
Washington	30.05	30.12	30.0[illegible]
Savannah	30.02	30.05	29.98
Nashville	30.00	30.05	29.97
Chicago	29.99	30.02	30.02

TABLE V.

AVERAGE TEMPERATURE.		
	Sept. 1st–10	Dep't from normal.
Boston	60.2	−4°
Washington	68.2	−2°
Savannah	77.4	0
Nashville	71.9	−½°
Chicago	58.8	−7°

Table V gives the average temperature of the first ten days and their departure from normal, showing that the prediction was fulfilled at every station except Savannah. The lowest pressure of the month did not occur between the 2nd and 5th, but the highest since June occurred near the middle.

A summary of the percentages of verifications for each month is given in Tables VI to VIII.

TABLE VI.

GENERAL PREDICTION FOR THE MONTH.	Pressure Per cent.	Temp. Per cent.	R'fall. Per ce't
May........	....	00	40
June	45	50	50
July........	....	....	....
August....	50	95	90
Sept	90	100	....
Average.	62	61	60

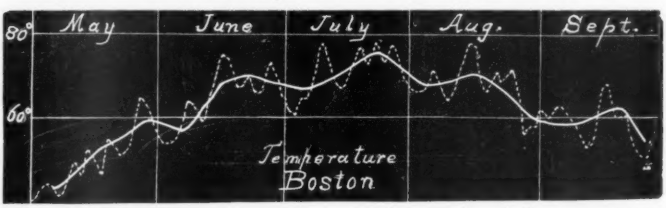
TABLE VII.

TEN DAY PREDICTION.	Pressure Per cent.	Temp. Per cent.
June........	87	50
July	70	75
August.....	90	....
Sept..........	80	80
Average.	82	68

TABLE VIII.

DETAILED PREDICTION	Pressure. Per cent.
July................	90
August...........	100
September.....	50
Average.........	80

Fifty per cent. of these average results might reasonably be assigned to chance, but it is seen that the figures at the bottom of each table exceed this in every instance, but the excess is not so marked as to demand attention except in table VII—though table VI shows a rapid rate of increase in the percentages of verification toward the last. Quite a number of cases are included in Table VII, and the percentage of verification was almost uniformly as much as 80%.* These predictions were based on a thirty day oscillation in the pressure and temperature which has been quite marked for over a year. (See the May JOURNAL). Its effect on the pressure was quite noticeable all the summer in the eastern half of the United States, but its influence on the temperature was more or less masked by other variations of long period at all of the stations examined except Boston. The dotted curve on the



accompanying diagram was constructed from the daily mean temperatures reported from Boston smoothed by getting the means of these, and the continuous curve is constructed from the means of

* None of this success can be attributed to normal seasonal variations for the predictions for higher pressure and warmer weather were made to alternate with predictions for lower pressure and cooler weather at too short intervals to admit of this.

every consecutive ten days. The upward rise of the curves toward July shows the annual sweep of the temperature; but besides this both curves show a rhythmical up and down movement occupying about thirty days, the lowest temperature occurring near the beginning of each month, and the highest near the middle.

To attribute the success shown in Table VII to chance, would it seems to me require an unreasonable faith in the goddess of chance, and I can look upon it in no other light than a proof that the predictions were based on the facts of nature; but the time was too short for the proof to be as convincing as I should like; owing, however, to a lack of any general interest aroused in the subject I was unable to extend them farther.

The predictions as I said at the beginning were crude, but I feel confident that they represent one of the elements in a new departure in weather prediction: yet, involving as it does the collection and reduction of data from very numerous stations, and the considerations of very complicated actions, it can not hope to reach its full development by the labors of one individual, but only by combined effort sustained by the requisite capital. This question of long period changes is receiving considerable attention abroad by trained meteorologist, especially in India; and I feel hopeful for its future development, though I should be glad to see our own country share part of the honor. H. HELM CLAYTON.

CAMBRIDGE, MASS., Dec. 12, 1885.

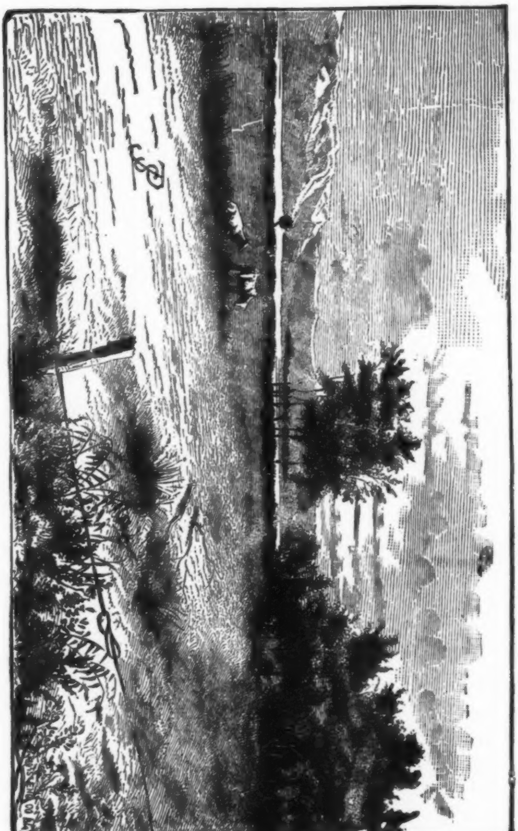
A WINTER JOURNEY ON THE NORTHERN PACIFIC RAILROAD.

The physical characteristics of the territory through which the Northern Pacific Railroad runs are even more remarkable than those of the other transcontinental roads, and, as the road has been opened for a shorter time, they are not so generally understood. This led me to undertake a trip across the continent on this route, and the unexpected claim of the officers that they had less to contend with in the way of snow than the central route, caused me to select the holidays as the time of my journey. I found several climatological and geographical problems of great interest, not yet fully discussed. I propose to leave them for further study

and to give in this paper only some general impressions which may be of general interest.

If one is in Manitoba or Northwestern Minnesota in winter and wishes to go to a warmer climate, he can traverse the isotherms at nearly a right angle by going either south or west, and to strike any given isotherm, say that of 40° for winter, the distance is not much greater toward the west than toward the south. The Northern Pacific crosses the isotherms to the west, and the traveller on its road finds, with a surprise which previous information does no entirely prevent, that he is passing gradually and steadily into warmer regions. The evidences of higher winter temperature begin as soon as he crosses the Red River at Fargo from Minnesota to Dakota. The change is already sufficiently marked to attract cursory attention when the Missouri River is reached at Bismarck or Mandan. The water-shed between the Winnipeg or Saskatchewan Valley and that of the Mississippi is not so marked as to attract the attention of any one not looking for it. Indeed it is not so so noticeable as that between the James River, a tributary of the Missouri, and the Missouri itself. The latter are the Coteaux of the Missouri, which further north separate the Missouri River from the Mouse River, a tributary of the Saskatchewan system. The Coteaux form a plateau of rolling hills, with many ponds and lakes without outlet. The elevation is not great (about 1,875 feet at the highest point on the road), and they are less than 300 feet above the Missouri River at Bismarck and Mandan. They are, however, believed on the ground to have a marked effect on the climate. Thoughtful residents claim that they form a distinct dividing line between the severe climate to the northeast of them and the milder climate to the west. It is thought there that they are the limit of the warm westerly winds, called the chinooks, and that the path of the northwestern blizzards is to the east. These blizzards are felt as far west as Helena, Montana, but their central paths are thought to lie east of the Coteaux.

The signs of a milder temperature continue to increase as one goes westward. The mildness is unmistakable when the Little Missouri River is reached and the traveller finds himself in the Bad Lands. They are certainly not bad in their winter aspect.



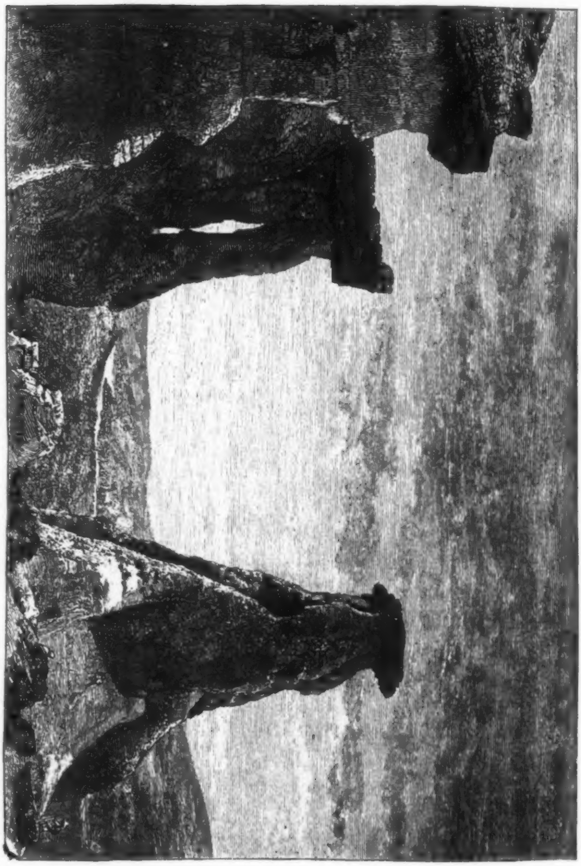
Scene in Knife River Valley, Western Dakota.

Just beyond them is the line between Dakota and Montana, and, on crossing it, one also crosses the winter isotherm of 15° which traverses Lake Superior nearly lengthwise, and after bending southward nearly to Huron, Dakota, then strikes northwestward, leaving the United States on the northern Montana line.

Through Montana the temperature for winter is evidently mild, and is largely a matter of elevation. In this territory the road makes its passage across the Rocky Mountains, and the highest elevations are reached, yet the temperature was not severe. In the Yellowstone Valley they were ploughing, and everywhere, on suitable pasturage, droves of cattle and flocks of sheep were out grazing. In western Montana the road turns well to the north, and in northern Idaho it attains a latitude of about 48°, yet, just beyond this, it crosses the winter isotherm of 25°

On crossing into Washington the winter isotherm of 30° is crossed and well west that of 35°, and then that of 40°—the isotherms from 25° on, here lying nearly parallel to the coast. The traveller now finds himself in a region where spring seems to have begun in the holidays. Every thing is green,—not only the evergreen trees but the mosses and liverworts give a lively green to the view, and though the deciduous trees have lost their leaves, the buds of the early ones have already begun to swell, and the willows show their premonitory yellow. Spring announces herself before the year is fairly ended, and there is no room for winter.

Accompanying the question of winter-temperature is that of rain and snowfall. So far as these are concerned the phenomena are very marked. The depth of snow gradually decreased until it was entirely lost in the valley of the Yellowstone. From there to the main ridge of the Rockies, beyond Helena, the country was evidently dry. The grasses were those of dry plains, and irrigating ditches were common. As soon as the backbone of the Rockies is fairly passed, one finds himself again in the region of heavier precipitation, and the signs of this moisture go with him to the Pacific coast. Eastward in western Montana and Idaho where the mean temperature is below the freezing point, the precipitation is of course snow. Near Pend d'Oreille the snowfall is said to be from four to six feet. In the lower Columbia Valley it is



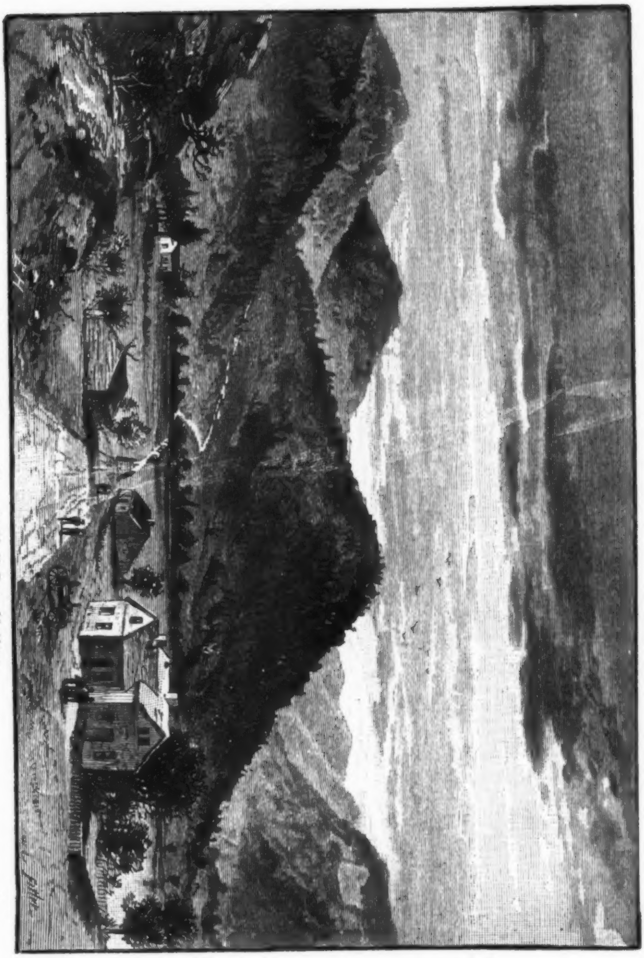
Scene in the Bad Lands of Dakota.

generally rain. Between these extremes, in Eastern Oregon and Washington, there is a dry belt running nearly north and south, just in the lee of the Cascade and Blue Mountains. It is 200 or 300 miles wide.

That the Northern Pacific need not be much troubled by snow, is evident from the above facts. It is also evident from the fact that no snowsheds are to be seen along the entire route. Snow fences are common, but of snowsheds there are none. On the Central route the sheds are so common as to be a serious annoyance to the traveller, in that passing through them is accompanied with the same discomforts as passing through a tunnel. A cutting from the recent newspapers states that the Central Pacific has recently completed an almost continual line of sheds forty-five miles long.

The snowfall on some points of the northern line is sufficiently deep to cause annoyance, and may occasionally make a blockade. In the Pend d'Oreille region, however, where the winter snowfall is about five feet, the country is very heavily timbered and there is little chance for the snow to drift. Snow blockades have, however, occurred. When the road was first opened there was a serious one in Dakota, and last winter there was a still more serious one in the Dalles of the Columbia. The latter was recognized as a rare phenomenon; no such snowfall had been known there for a score of years or more. At the eastern end of the line the road is more exposed to blockades, but it is only fair to say that, in this, it is in the same condition as all other roads crossing the Upper Mississippi River.

The relative freedom from blockades of the Northern Pacific is due in part to the dryness of the central part of its route; in part, also, doubtless to its relatively low elevation. The Rockies of the northern tier of territories do not assume the elevation which they have farther south. The most notable of the northern mountains are not in the Rockies, but in the Cascade range. The greatest elevation of the Northern road is reached at the Bozeman tunnel, over the Belt range, an outlying range of the Rocky Mountains. The elevation here is 5,572 feet, far below that at Sherman of the Union Pacific, or that of the Atchison, Topeka and Santa Fe, at the Raton Mountains. The main ridge of the Rockies is

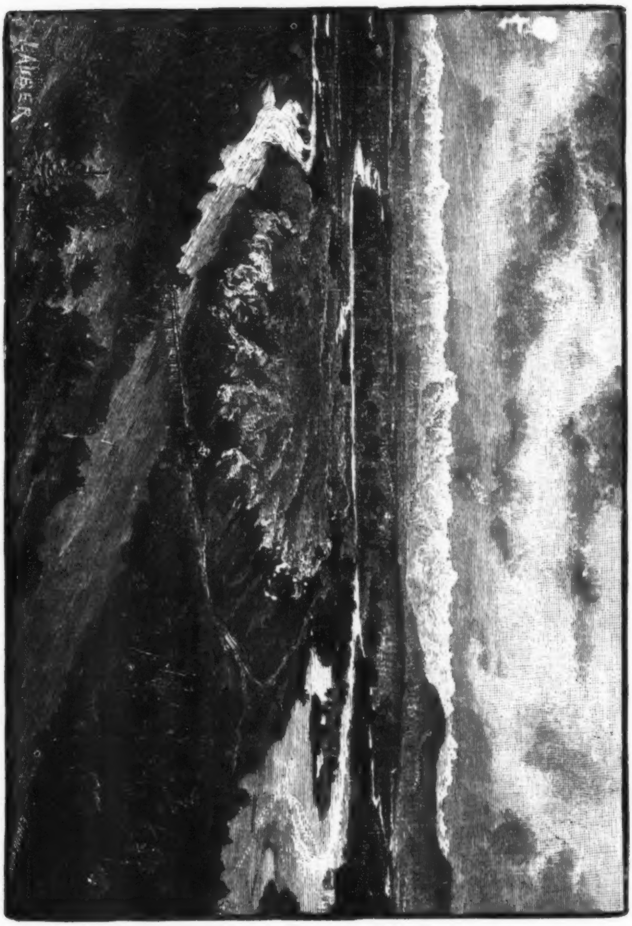


A Montana Farm.—View in Hell Gate Valley.

passed at a slightly less elevation. This is at Mullen's pass, and the elevation is 5,547 feet. As the present route follows the Columbia through the Cascade range, the elevation is there slight. When the Northern Pacific is completed across Washington Territory to Tacoma, it will make a transit across this range at Stampede pass, the elevation of which is, however, only about 2,850 feet.

The traveller is impressed on this route by the character of the limits of the treeless prairies. Beyond the Red River trees are rare until the great divide is passed. The forests then become fine, and so continue, with increasing size of trees, until the coast is reached. The only exceptions to this are the prairie regions of eastern Washington. Beginning in Idaho with well marked small prairies limited by dense forests, they increase and the forests dwindle in size, compactness, and size of trees, until the sandy plains just east of the Cascade range are reached. Passing them, the forests, at a bound, reach a magnificence far surpassing that of the Pend d'Oreille region. The eastern limit of each of these regions of prairies is ill-defined and apparently not placed by nature. The western limit, on the other hand, is sharp and is formed by a great mountain ridge. The prevailing winds are westerly. To the windward of the north and south mountain ridges the forests are unusually great. To the lee of the same mountains the forests disappear, to appear again at a longer or shorter distance from the mountains. The causes are of course not far to seek. They are to be found in the action of the mountains on the moist air approaching them from the west. On approaching the mountains the air is chilled and the moisture deposited on their western flanks. These would support a strong forest vegetation, while the eastern flanks would be too dry.

That the eastern limit of the prairies is not a natural one, is indicated by the ease with which trees can be grown when planted. The timber-culture act has given a stimulus to tree culture, and the road has itself planted trees along some parts of its course to aid in protecting from snow. Notwithstanding the efforts of the general government and of the railroad the western settler does not seem to have yet overcome entirely his feud with trees. Many cabins, apparently several years old, stand out on the bleak



Three Forks of the Missouri.

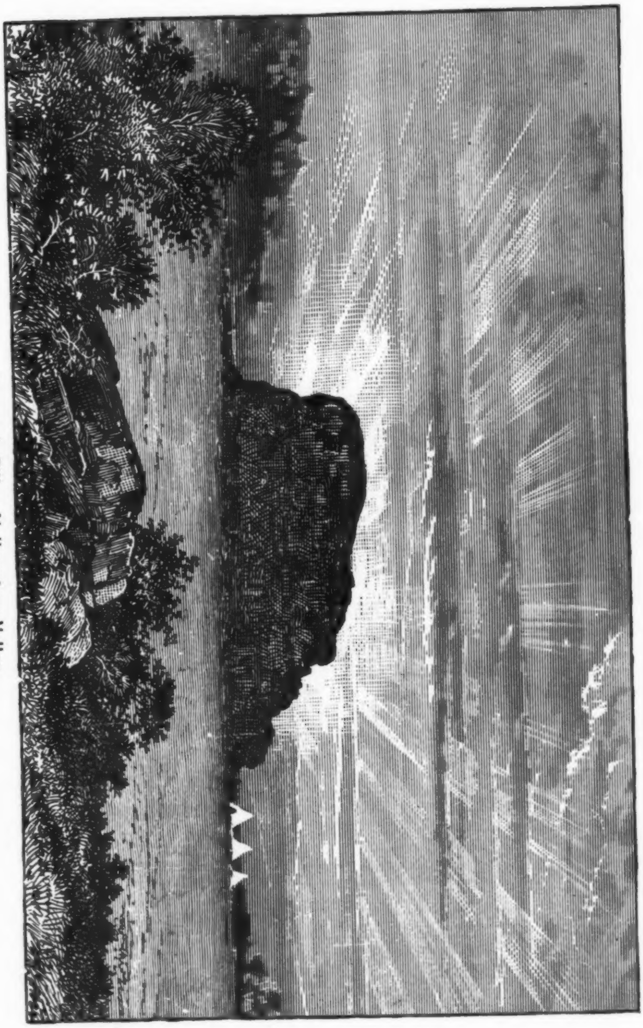
prairie without the sign of a tree, and in such towns as Bismarck the absence of trees makes a cheerless impression upon the observer.

As to the character of the country passed through, the Northern Pacific is the only transcontinental route the entire course of which is continuously inhabitable. Only in the deep forests of northern Idaho does the traveller find himself out of sight of civilization. Everywhere else it is rare to look from the car window and not see either a cabin or a fence or both. The Dakota plains are not unnattractive in appearance. The absence of trees is relieved in the river bottoms, and in the proper season the prairie vegetation is one of surpassing attraction. The country is not so level as farther south, but is undulating, giving an appearance of hills on the horizon.

The Bad Lands are decidedly good lands for the farmer or stock-raiser. They receive their names from the fact that for the old voyageurs they were *mauvaises terres à traverser*, which with American carelessness has been shortened into *mauvaises terres* and this translated into Bad Lands.

It is as easy to curse a country as a dog by a bad name. A small stream in a healthy and excellent district in Iowa is called Fever river and is naturally avoided by the immigrant. The origin of the name is said to be this. It was named after a Frenchman named Le Fevre (meaning the blacksmith and corresponding in frequency to the English patronymic Smith.) Le Fevre's river was in time shortened into Fevre's river and this into Fever river. No one would willingly settle on a stream called by the ominous name of fever; if the name had, however, been translated into Smith's river, the bad omen would not have existed.

It is proposed to change the name of Bad Lands to Pyramid Park. This name would be appropriate for in cutting out their beds the streams have left many remarkable pyramidal forms. The Bad Lands are very rough but also rich. The soil is rich, the grasses are luxuriant, coal is so abundant that surface beds take fire and burn for months or years. Medora is a fine town and the school house and newspaper have penetrated there. The *Bad-Lands Cow-boy* has probably as picturesque a name as any paper in existence.



Pompey's Pillar, Yellowstone Valley.

Montana fully justifies her name. She has many level valleys but they are usually but a few miles wide and are everywhere overtopped by mountains.

These valleys are often suitable for agriculture. The climate is mild and they are protected by the surrounding mountains. West of the mountains the valleys almost invariably need irrigation, but the mountain streams are abundant or the river of the valley affords an abundant source of water. Frequently the valleys are not rich enough for good farming but they are invariably covered with nutritious grasses, on which stock can feed all winter long. This is remarkable for a region lying on our northern border and largely east of the Rockies. It is nevertheless true that stock here take care of themselves better in winter than in the regions immediately south. The light snowfall contributes to this result, and the dry air cures the grass standing so that in the fields it is good, nutritious natural hay. The dry climate and the nutritious grasses make the territory excellent for sheep, and these characteristics with firm soil give excellent results in rearing horses, those bred being superior.

The valley of the Gallatin is one of the best in Montana and here is a town (Bozeman) of considerable age. Here is a considerable expanse of level land, well cultivated and fertile. At its lower end, and within sight of the road, the three streams meet which give a good body of water to the Missouri. The three forks are the Gallatin, the Madison and the Jefferson, each a considerable stream. The region is a low one, covered with scrub, but off in the distance in every direction mountains are in sight.

This part of the route (along the Yellowstone and Gallatin) is especially picturesque and was considered by the Indians one of their best ranges, the possession of which they contested stubbornly. The Yellowstone Park is near by, across a range of mountains through which the Yellowstone penetrates. Less known is Pompey's Pillar which is so characteristic of the region that we herewith present a cut of it. It is on the Yellow stone, and is a yellow mass of sandstone rising abruptly 400 feet above the valley level. Its base covers about an acre of ground. On the top is a deep soil and from it the view is superb. It was a favorite spot

for the Indians who carved in its sides figures of animals and other objects. About half way up Captain Clark, of the Lewis and Clark expedition, carved his name in 1806.

Northern Idaho is heavily wooded and very picturesque. It is not in general suitable for agriculture, where the road runs through it. Of Eastern Washington mention has already been made. Its soil is derived from basalt and it has occasional very rich valleys. As one approaches the Cascade range the mesa character of the country becomes marked and then fades away into sandy plains. Coulees, or old water courses, no longer needed for the drainage of the country, are numerous and characteristic. Then there is a not very wide stretch of rolling plains with drifting sands apparently not suitable for dense settlement. Dune structures are there predominant.

The traveller then passes on to the Cascade Range and goes through one of the most picturesque regions in the world. He accompanies the great Columbia through the mountains. As soon as he has penetrated them he becomes aware of the great propriety of their name. Water, so lacking on the western slope, is very abundant on the Eastern. Cascades pour down from every nook in the rocks. The streams are not large but they come down hundreds of feet and one has hardly passed out of sight of one before he comes to another, surpassing perhaps what he had thought a moment before could not be surpassed. Multnomah falls is made by a considerable stream plunging down 800 feet with but a single break. Bridal Veil comes over the edge of rock with a good body of water but is entirely lost in spray, streaming out on the wind, long before the bottom is reached. Meantime can be seen, in favorable weather, snow-clad, giant mountains, Mt. Hood, Mt. Ranier, St. Helens, and others less renowned. Meantime the vegetation grows more and more vigorous until the maximum is reached on the Pacific coast or on Puget Sound, where the cedars and pines sometimes go up one or two hundred feet before the limbs are reached. So prodigal is nature with the trees that man is also prodigal. The wood chopper builds a frame eight to twelve feet high from which to cut them, leaving stumps of corresponding height, and the settler, tired at the very prospect of cutting them down, burns them out without mercy. Here is an older civilization than in the intervening territories, and here I will end my notes.

M. W. Harrington.